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The Fast Test Reactor (FTR) is a sodium-cooled, mixed-oxide fueled, 400 MW (Th) fast reactor designed for irradiating experimental FBR fuels and materials. The reactor is located near Richland, Washington, and is operated by the Westinghouse Hanford Company for the USDOE. The FTR reached initial criticality on February 9, 1980, with 59 fuel assemblies in the core. It was then shut down to continue loading additional fuel needed for the startup testing configuration. This paper summarizes the fuel loading process and preliminary results through initial criticality. The final paper will include a status summary of physics tests through mid summer, 1980.

The arrangement of the principal reactor internal components is shown in Figure 1. The core is covered during operation by three instrument trees, each monitoring coolant outlet conditions within a one-third sector (trisector) of the core. For refueling, these rotate away from the core to allow access for three in-vessel handling machines, each of which services one trisector and has its own in-vessel storage positions and ex-vessel transfer port. Because their drivelines pass through the instrument trees, the three control rods in any trisector are inoperable (remain inserted) when refueling is in progress in that trisector.

A conventional symmetric fuel loading process from the center out, with control rod withdrawals at intervals to assess rods-out reactivity is inefficient for the FTR because:

1. Fuel transfer equipment must be repeatedly moved from one ex-reactor transfer port to another in order to service all three sectors in sequence; and

2. For each withdrawal of all nine control rods, all three in-vessel handling machines must be parked, the instrument trees rotated over the core, and control rod drivelines connected.

These disadvantages were circumvented by loading one trisector at a time, and connecting the control rod drivelines in each sector after it was loaded so that the rods could be operated during the loading of subsequent trisectors. This sequence was interrupted once during the loading of the final sector, to achieve initial criticality at an approximately minimum critical loading and to measure absolute subcriticality by the rod drop technique. These measurements were sufficient to monitor subcriticality during the balance of the fuel loading without the need for further rod withdrawals to critical or near-critical conditions.

To investigate potential problems with this scheme, measurements had been made earlier with neutron counters on configurations of the FTR critical experiments in the ANL ZPR-9 facility, designed to simulate typical asymmetric and partially-loaded conditions.[1,2] The general conclusions from these experiments were:

1. An in-core detector was preferable to the standard FTR ex-core detectors for monitoring the initial fuel loading, due to its smaller and more accurately predictable changes in detection efficiency;

2. With an in-core detector, the core could be loaded safety and count rate readings interpreted satisfactorily, even for the highly asymmetric sequence of core configurations reached in the trisector loading scheme.

Consequently, special fission chambers were installed in an instrument thimble near the core center to monitor the initial fuel loading. The thimble is later to be used for a variety of nuclear characterization measurements, prior to commencing power testing.

Because of the changing detection efficiencies as the core is loaded and the inability to obtain count rate data in the most reactive or all-rods-out state without the expenditure of considerable time for coupling and uncoupling control rod drivelines, extensive preanalyses of the various partially loaded conditions were made and the calculated results were used as a guide in interpreting the available count rate data. The calculations were made with a two-dimensional (midplane) multigroup isotropic diffusion theory model, and different spatially varying buckling models were employed to represent the axial leakage from the (largely sodium filled) unfueled regions of the partially loaded core. The capabilities and limitations of these techniques were established by comparison with the FTR critical experiments. The integration of preanalyses, critical experiment results, and neutron counter data from the FTR instruments can be illustrated by the initial withdrawal of all nine control rods to achieve criticality. It was desired to go critical at the earliest practical stage in loading, which meant interrupting the fuel loading process in the final trisector before it was fully loaded to rotate the instrument tree, connect the remaining three control rods, and make other time-consuming preparations for criticality. The decision to attempt criticality had to be based on count rate data obtained with the three control rods in the final trisector inoperable, and fully inserted. Therefore, calculations were relied upon to establish the nominal core reactivity level, worth of the remaining three inserted control rods, and the impact on relative count rates of small deviations from nominal, calculated core behavior. In addition, rod worth measurements and count rate ratios were available from the critical experiments for a partially loaded core very similar to the anticipated critical condition. From these data, a loading of 57 to 58 fuels appeared to be capable of criticality with all rods out. An additional fuel (number 59) was added for 'insurance,' and the reactor was then critical with an equivalent rod bank height estimated as 31.3 inches (secondary rods) out of a total core height of 36 inches. A nominal critical loading with all rods out (36 inches) is estimated as 58, in excellent agreement with earlier estimates[3] which placed the critical loading at 58 fuels. Other comparisons can be made between the experimental inverse count rate history, as a function of fuel inventory, and the precalculated values; as shown in Figure 2, and between the calculated worth of \$5.48 and measured worth of \$5.49 $\pm$ 0.06 for the primary control rod used in the rod drop measurement during the initial approach to critical.

Relatively few measurements were made at the initial critical loading, and they are less important to future operation than those to be made with a fully loaded core. However, the results of the FTR initial criticality are generally in good agreement with the calculations, showing that the analytical techniques originally developed for the analysis of fully loaded cores can be used with minor adjustments.

References

1. E. M. Bohn, "FTR Critical Assemblies," in Reactor Development Program Progress Report - September 1974, p. 6.3, ANL-RDP-32, Sepbember 1974.

2. J. W. Daughtry et al, "ZPR-9 Assembly 27: The Fast Test Reactor Engineering Mockup Critical (FTR-EMC)," in Applied Physics Division Annual Report - July 1, 1970 to June 30, 1971, pp. 33-39, ANL-7910.

3. R. A. Bennett et al, "Nuclear Startup, Testing, and Core Management of the FTR," presented at the IAEA Symposium on the Physics of Fast Reactors at Aix-en-Provence, France, September 1979.

FFTF REACTOR

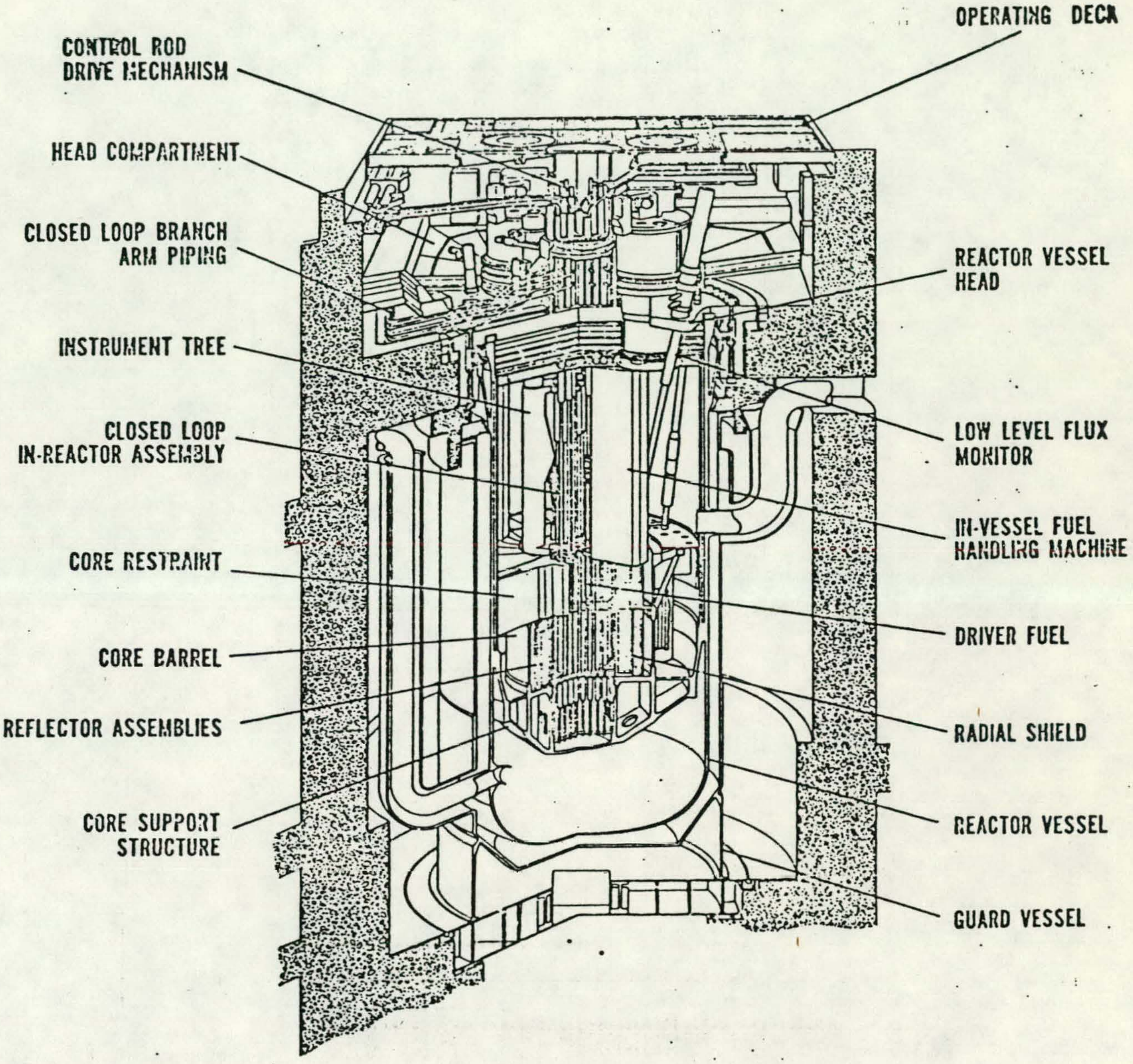

Figure 1. Reactor Elevation

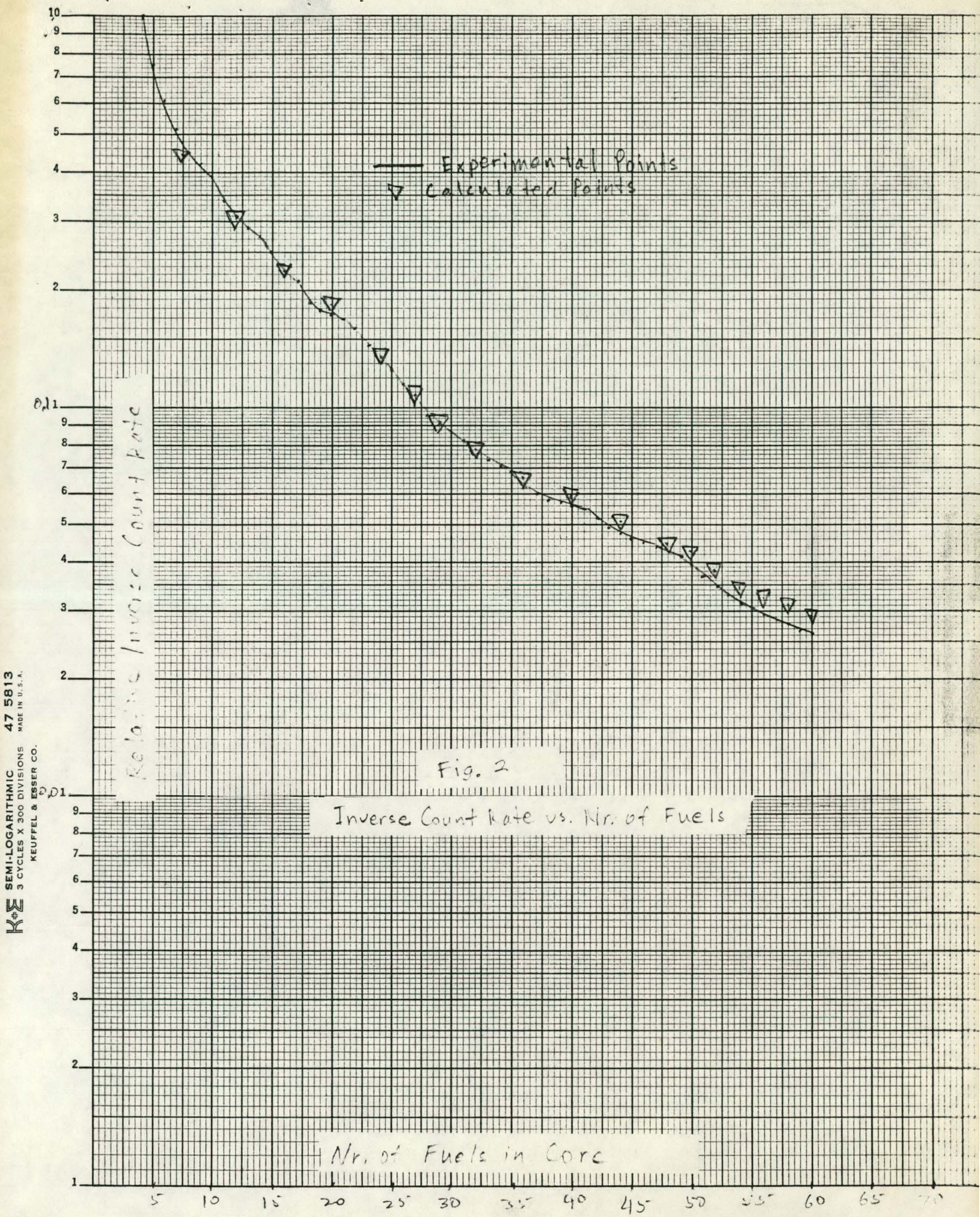

Fig. 2

Inverse Count Rate vs. Nr. of Fuels